1015-001

IDS 8/24/01

PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) **International Patent Classification** 6 :
H05K 13/08

A1

(11) **International Publication Number:** **WO 96/12396**

(43) **International Publication Date:** 25 April 1996 (25.04.96)

(21) **International Application Number:** PCT/SE95/01178

(22) **International Filing Date:** 12 October 1995 (12.10.95)

(30) **Priority Data:**
9403478-2 12 October 1994 (12.10.94) SE

(71) **Applicant** *(for all designated States except US)*: MYDATA AUTOMATION AB [SE/SE]; Karlsbodavägen 39, S-161 70 Bromma (SE).

(72) **Inventor; and**
(75) **Inventor/Applicant** *(for US only)*: JACOBSSON, Nils [SE/SE]; Fallskärmsvägen 31, S-175 63 Järfälla (SE).

(74) **Agents:** LINDÉN, Stefan et al.; Bergenstråhle & Lindvall AB, P.O. Box 17704, S-118 93 Stockholm (SE).

(81) **Designated States:** CN, JP, KR, SG, US, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) **Title:** REPRODUCTION OF COMPONENTS

(57) **Abstract**

A pickup head (2) for an automatic component assembly machine comprises several pipettes (1) placed next to each other, for retaining components (3) at the sucking nozzles of the pipettes. The pipettes are located in the same plane, and hence the individual components (3) have their centers along an approximately straight line. In reproducing the components (3) for an accurate evaluation of their positions in relation to the pipettes (1) a non-conventional lens system (5) is used, which has a larger magnification in a direction perpendicular to the approximately straight line through the components than parallel thereto. The pictures of the individual components hereby become extended perpendicularly to the line through the components. This provides a better utilization of the image points of the light sensitive surface (9) of a video camera (7) in the evaluation of the picture and thereby a more accurate determination of the positions of the components.

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REPRODUCTION OF COMPONENTS

TECHNICAL FIELD

The present invention relates to a simultaneous reproduction of a number of components, in particular components retained by a line of pickup devices in a component assembly machine, in particular an assembly machine for the automatic mounting of electronic and similar components.

BACKGROUND

Automatic assembly machines for electronic components conventionally have a pickup head, which fetches electronic components from different magazines and puts them on accurately determined locations on a circuit board. The pickup head can have a number of individual pickup devices or sucking pipettes whereby in a pick-up movement of the pickup head several components are fetched, so that after the pickup operation, the pickup head carries several components at the same time. For the accurate positioning of the components, automatic image processing can be used and then an image of all the simultaneously retained components is captured, when the pickup head and all its separate pickup devices, at which the components are retained, adopt an accurately predetermined reference position. The sucking nozzles of the pickup devices are then located in a row and thus the components are also generally retained in positions along a line. During image capturing, image fields or fields of view are conventionally used, which are generally rectangular and have dimensions, which do not differ too much from a quadratic shape, for instance having a ratio of normally 4:3 between the long and short sides of the image field at most. When components are reproduced by means of a device having such an image field, it will be possibly to use, in the image processing, only the central horizontal part of the image, parallel to the long sides of the image field, what provides a poor utilization of the captured image. In other words, when using an image processing device having discrete light sensitive elements such as a CCD-camera, only a few pixel points of the captured image will be used during the image processing, most of the pixel points being totally irrelevant for the information, which is to be extracted.

Conventional methods of capturing an image of a single component during automatic or electronic image processing can comprise one of the following:

- 1. Placing the component in front of a camera, in order to obtain one whole single image of the component.

- 2. Capturing two images and placing the component in such a way that one half of the component at a time is reproduced by the camera. Subsequently the two images are put together by an image processing routine. The two half images show the component in the same scale.

- 3. Capturing four images, each of which showing one of the four corners of the components, by placing the component at a suitable lateral location, but at the same distance from the camera. Thereafter the images are put together by an image processing routine. The

four images are captured in the same scale.

The use of lens systems producing distorted pictures has also been suggested in association with mounting electronic components, see U.S. patent US-A 5,249,239 and the Japanese patent application JP-A 63-122300. Typical distorting lens systems are also disclosed in U.S. patent US-A 4,158,134 and the Japanese patent application JP-A 57-204018.

SUMMARY

It is an object of the invention to provide a method and a device for capturing an image of several components placed in a row, having a good resolution of each reproduced component.

It is a further object of the invention to provide an automatic component assembly machine having an accurate reproduction of several simultaneously retained components, having in particular a good angular resolution to be used by an image processing system during the positioning of the components. These objects are achieved by the invention, the characteristics of which are set out in and the scope of which is defined by the appended claims.

For the reproduction, a lens system is used having different magnification in suitable directions perpendicular to each other.

Thus, a pickup head for an automatic component assembly machine comprises several pipettes located next to each other for retaining components at the sucking nozzles of the pipettes at their lower ends. The pipettes are located in the same plane, the separate components thus having their midpoints along an approximately straight line. In the reproduction of the components for an accurate evaluation of their positions in relation to the pipettes, a reproduction system is used, having a larger magnification in a direction perpendicular to the approximately straight line through the components than parallel thereto. The reproductions of the individual components become hereby extended perpendicularly to the line through the components. This provides a better utilization of the image points during the evaluation of a captured image, which can be captured by the light sensitive surface of a video camera for digital processing. A more accurate determination of the positions of the components can hereby be made.

Thus, components retained in a row of retaining devices are generally reproduced for an automatic evaluation of the positions of the components, by capturing an image of the components by means of an image capturing device, which has a larger magnification in a direction perpendicular to the component row than parallel to the component row. For this purpose an image capturing device is arranged in front of or underneath the components, when they in one case pass the image capturing device or when they in a second case stop to remain in a reference position of the retaining devices. The image capturing device then presents a larger magnification in a direction perpendicular to the component row than parallel to the component row. The retaining devices are located on a pickup head, which in

the first case can comprise an indication or reference surface stiffly mounted at the pickup head, placed in such a way that it is at least partly located inside of the field of view of the image capturing device during the capture an image of the components.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described by way of a non-limiting embodiment with reference to the accompanying drawings, in which:

- Figure 1 is a schematic perspective view of parts of a pickup head for an automatic component assembly machine, having schematically shown optical devices for capturing an image of retained components,
- Figure 2 is an image of the retained components captured by conventional optical devices,
- Figure 3 is an image of the retained components captured by specially designed optical devices and
- Figure 4 is a perspective view of a component assembly device.

DETAILED DESCRIPTION

In the upper part of Figure 1 the lower portions of pickup devices or pipettes 1 are shown, belonging to a component pickup and placement head 2 of an automatic assembly machine for electronic components. The pipettes 1 are arranged in parallel to each other at an equal spacing and retain components 3 at their lower ends, where sucking nozzles are located. The pickup head 2 is placed on an x-wagon, which is moveable in a lateral direction, the x-direction.

An image capturing system, comprising a lens arrangement 5 and a video camera 7 having a light sensitive surface 9 comprising an array of CCD-elements is placed underneath the path, along which the components 3 pass from a pickup place to a placement location, and it can capture an image from underneath of the components, when they are in a suitable position. The image captured by the video camera 7 is communicated to an image evaluation device 7', where a determination of the positions of the components is made, the result of the determination being then transferred to a control unit 7" arranged to control the movement of the pickup head 2 and the movement of the individual pipettes 3 in relation thereto.

The image obtained by means of a conventional lens system 5, is schematically shown in Figure 2 as a rectangular image field 11 and individual pictures 13 of the components 3 therein. The pictures 13 are located along a row in an approximately straight line, for a typical adjustment of the system in the middle of the image field 11, the center lines of the component pictures extending in parallel to the long side of the image field. Owing to the arrangement along a line of the components 3 and hereby of their pictures 13, only the central portion of the image field, where the individual pictures are found, is normally used, at least if the components 3 are not too elongated, and thereby information only needs to be taken from this area during an automatic image processing of the signals from the light sensitive elements of the surface 9. The information from other light sensitive elements is not used since they do not contain any information.

Instead, as a lens arrangement 5 in front of the video camera 7 a nonlinear lens system having different magnifications in different directions can be used. This can be obtained by means of specially calculated lens devices, compare e.g. the above cited patent applications and patents, which are incorporated herein by reference. Such a lens system is then adjusted so that a maximal magnification is obtained perpendicularly to a straight line passing approximately through the centers of the individual pictures 13 according to Figure 2, a smaller magnification being set in a direction parallel to that line. The image obtained in that way can become as is schematically illustrated in Figure 3. The obtained separate pictures 13' of each component within the image field 11 are then elongated in a direction perpendicular to the straight line through the centers of the individual component pictures and thus also to the sides of the image field 11, in the preferred case to the long sides. These pictures can occupy a large portion of the image field 11, so that considerably more light sensitive elements of the light sensitive surface of 9 of the video camera 11 can be used by an automatic image evaluation system.

A higher accuracy is hereby obtained, primarily of the angular positions of the individual components, i.e. the rotated positions thereof in relation to some initial position, which for instance is the position in which their long sides are located perpendicular to said line, by obtaining a longer side of the reproductions 13' in a transverse direction, perpendicularly to the line. There is also a better accuracy in the determination of the positions of the components in a transverse direction since deviations from the centre line are enlarged by the optical devices. One can also obtain a better accuracy in a longitudinal direction, parallel to the central line, since there are more individual picture elements which indicate the position of the outer sides in the transverse directions, which results in a better statistical significance.

The anisotropical optical system 5 can produce some distortions in the obtained image, that is it can become distorted compared to the ideal image, which is illustrated Figure 3. In particular at the corners of the image field, reproduction errors can occur and also generally in areas next to the sides of the image field 11. However, this effect is not disturbing, since a calibration of the image field can be made easily by placing a calibration plate having some regular known pattern, for instance dots placed in a quadratic lattice or a square pattern, in the area, which is projected on the light sensitive surface 9 of camera 7.

According to a first embodiment all the pipettes 1 and the pickup head 2 are assumed to be located in a reference position, during the capturing of the image of the component 3, for which position the positions of the pipettes and the pickup head are accurately determined and known. According to a second embodiment the image can instead be captured, when the pickup head and its parts pass continuously over the reproduction system. The elements of the light sensitive 9 of the camera 7 are then activated only during a very short time in order to capture an image of the component 3, which is equivalent to opening the shutter of a conventional camera for very short time. This might require extra illumination of the

components in this position, and lamps 15 can be arranged on both sides of the path of the components 3.

In this case there is no given reference position, to which the fixedly set reproduction system and its evaluation circuits for the captured image can relate the positions of the components 3. Therefor, a reference can be arranged in the captured image itself by attaching stiffly to the pickup head 2 a reference projection 17, which extends in parallel to the longitudinal direction of the pipettes 3 and which has a lower surface, which is located in approximately the same plane as the bottom side of the components 3 or can even be allowed to be located at a distance behind this plane, as seen from the video camera 7. For a suitable location of the under surface of the projection 17 it will be reproduced in the captured image field, as indicated at 19 in Figure 2 and at 19' in Figure 3. If the pipettes 1 with their lower surfaces only project a small distance beyond the bottom surface of the pickup head 2, instead of a reference projection equivalently a reference mark attached to this very bottom surface can be used.

In Figure 4 a component assembly or pick-and-place machine is illustrated in a perspective view showing the general configuration of such a machine. A wagon 401 is movable along a horizontal bar 403, in the x-direction, to different locations, such as above magazine sites 405 intended to hold component feeders, which are movable in a horizontal direction, the y-direction, perpendicular to the guide bar 403 and above a circuit board 407 retained on a slide, also movable in the same direction as the magazine sites 405. The wagon 401 carries a pickup unit or head 2, from the lower side of which the vacuum pipettes 1 protrude downwards. The optical reproduction system including the video camera 7 can be located on one of the magazine sites 405 or at the x-wagon 401 itself, if suitable mirrors are placed in the paths of the light rays.

CLAIMS

1. A method of reproducing components retained in a row or a line for an automatic evaluation of the positions of the components, **characterized in** that an image of the components is captured by means of an image capturing device having a larger magnification in a direction perpendicular to row or line of components than in parallel to that row or line.

2. An arrangement for reproducing components, which are retained in a row, for an automatic evaluation of the positions of the components, **characterized by** an image capturing device arranged in front of or underneath the row of components, when the components are located at or pass the arrangement, the image capturing device being arranged to have a larger magnification in a direction perpendicular to the component row than in parallel to the component row.

3. An arrangement for reproducing components, which are retained in a row by retaining devices, for an automatic evaluation of the positions of the components, **characterized by** an image capturing device arranged in front of or underneath the components, when the components are in a reference position of the retaining devices, the image capturing device being arranged to have a larger magnification in a direction perpendicular to the component row than in parallel to the component row.

4. A component assembly machine comprising a pickup head having retaining devices for retaining components along an essentially straight row or line and further comprising a system for automatic evaluation of the positions of the components, **characterized by**

- an image capturing device arranged in front of or underneath the components, when the retaining devices or located at or pass the image capturing device,

- the image capturing device being arranged to have a larger magnification in a direction perpendicular to the straight row or line through the components than in parallel to the row or line through the components.

5. A component assembly machine according to claim 4, **characterized in** that the pickup head comprises an indication or reference surface stiffly attached thereto, the indication or reference surface being placed in such a manner that it is at least partly located inside the image field or field of view of the image capturing device in capturing an image of the components.

6. A component assembly machine, comprising retaining devices for retaining components and further comprising a system for an automatic evaluation of the positions of the components, **characterized in**

- that the retaining devices can adopt a reference position with the components placed along an essentially straight line,

- an image capturing device arranged in front of or underneath the components, when the retaining devices are in the reference position,

- the image capturing device being arranged to have a larger magnification in a

direction perpendicular to the essentially straight line through the component than in parallel to the line through the components.

Fig. 1

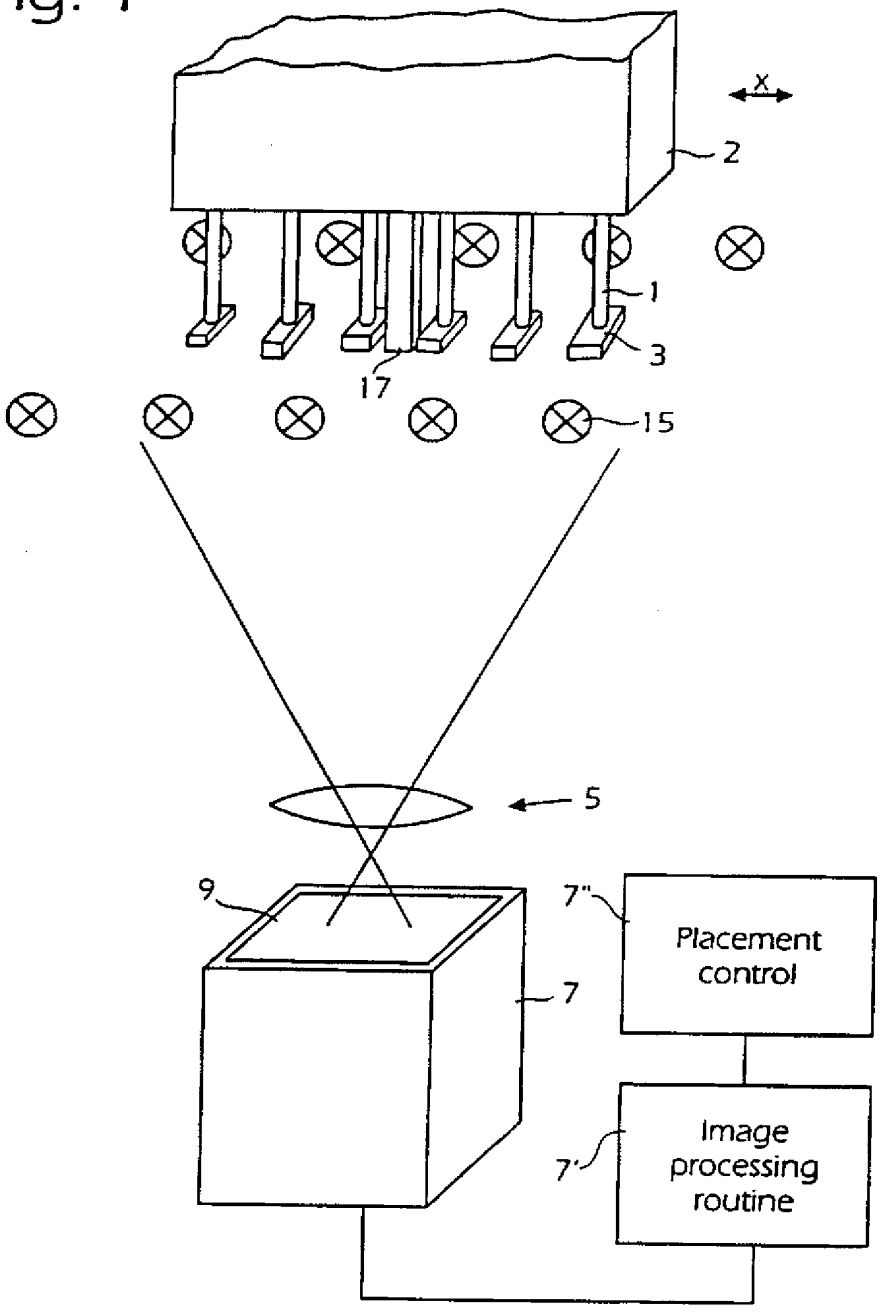


Fig. 2

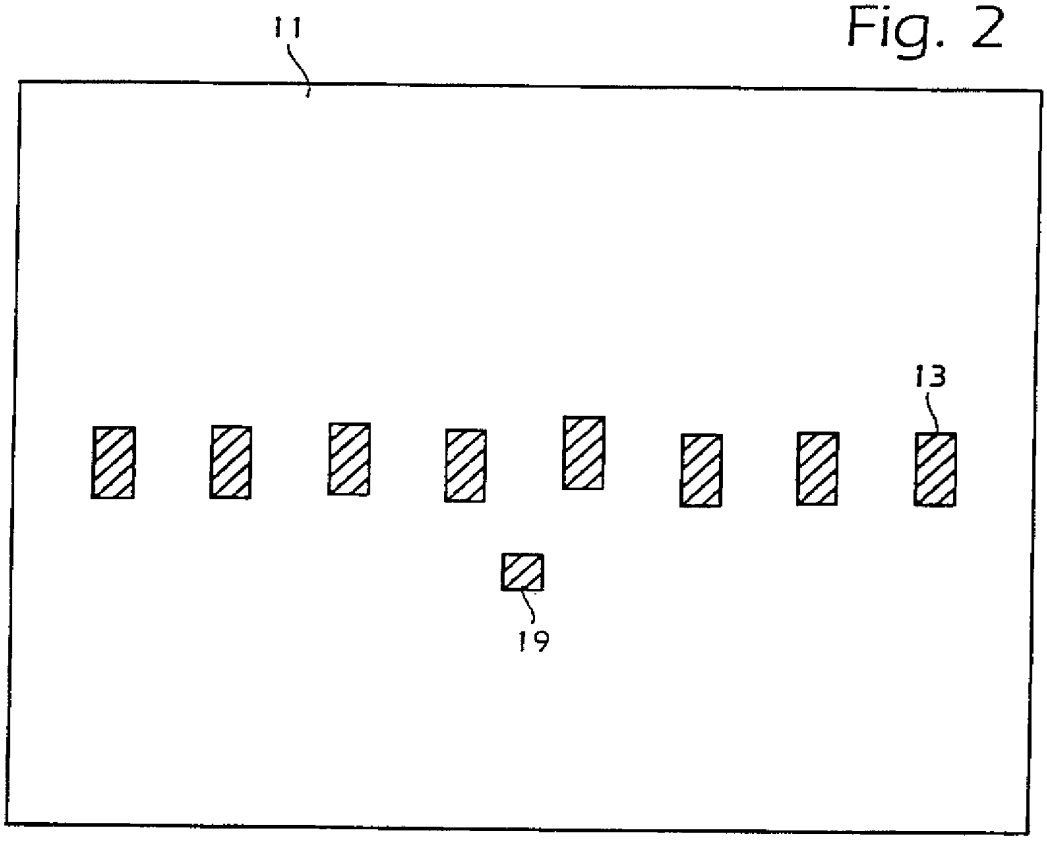
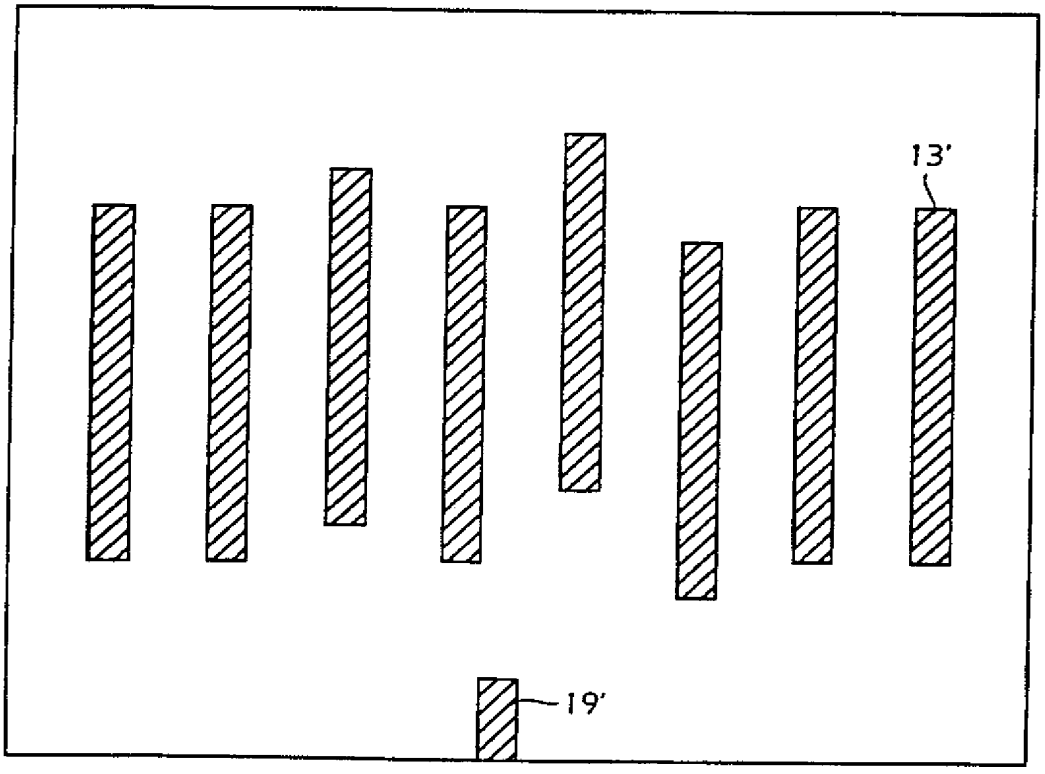


Fig. 3



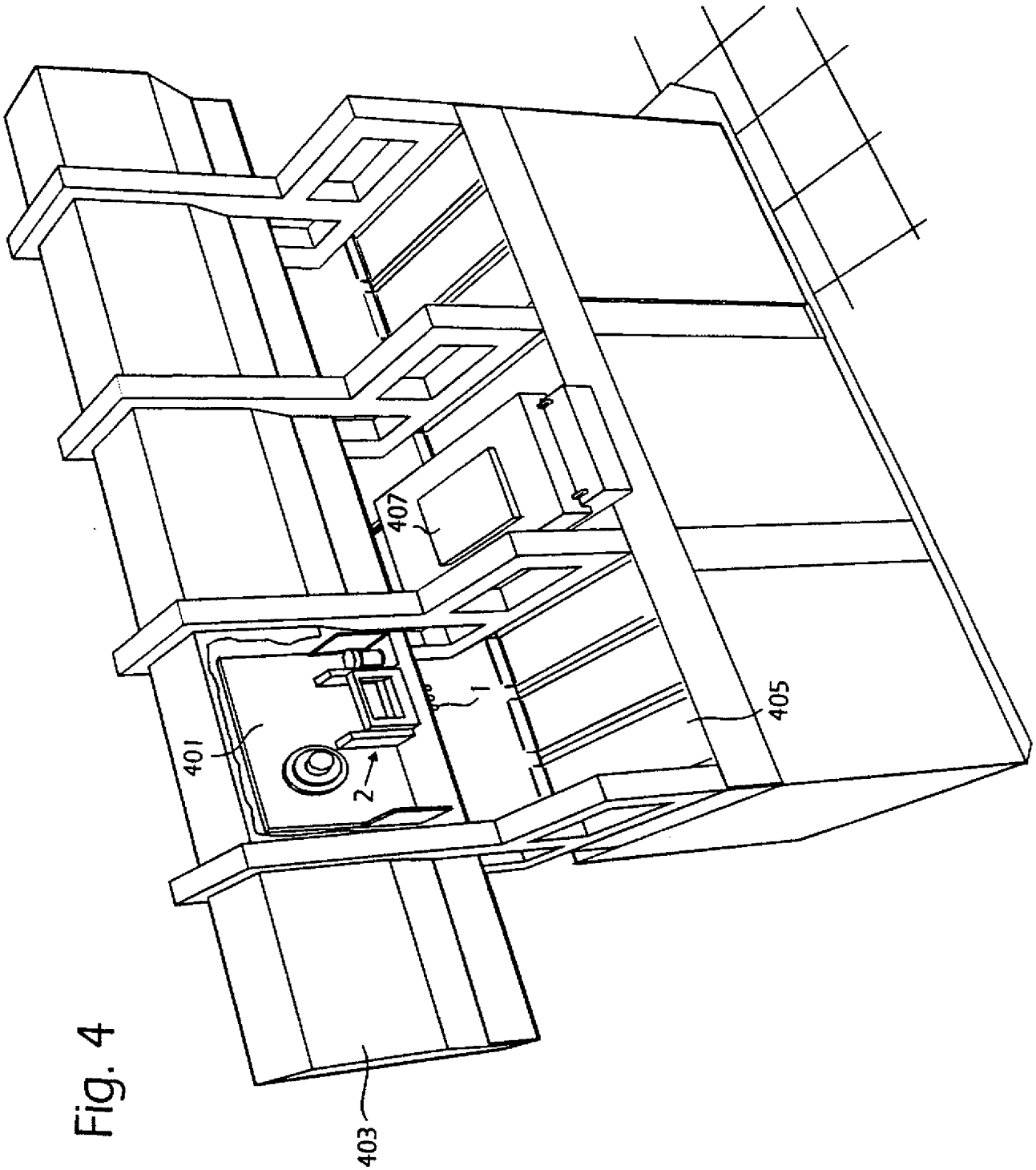


Fig. 4